

Efficient Spectrum Utilization in Cognitive Radio Networks

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ABSTRACT: Joseph Mitola termed the word “cognitive radio ” for the first time during his seminar at the royal institute of Stockholm, Sweden in 1992. A smart SDR that is capable of automating the changes in the channel allocation in the neighbouring vicinity with the varying capabilities of its receiver without the human intervention. It senses a challenge in the interference loaded channels rather than considering it to be worthless for communication. Though in-network computations have been put forth to find the free-lying channels, as well as different handoff schemes has been termed yet there were no better mechanisms to allocate the vastly under-utilized spectrum pools. In this paper, the various marketing mechanism are uses that treat the spectrum bands as pools and goods that are auctioned and bided by the secondary user.

KEYWORDS: Dynamic spectrum sensing, Cognitive radio networks , Combinatorial Auction, Time Frequency division.

I. INTRODUCTION

The cognitive science though in its level of infancy has reached a phase where it has begun its venture in assisting not only the 4g spectrums but also 5g spectrums vastly. Even though, the practical implementation of a fully cognitive radio might take 50 to 500 years, the spectrum sensing cognitive radio networks has made a niche in the wireless networks. The various uses of the CR networks usually range from around smart home applications, the “geo-spatial fencing” in military applications and in the telemetry. The need for emergency medical help during the 911 attack and when a firework factory exploded in Netherlands killing thousands in number, the proper medication could not reach on time because of the difference in the various transceivers and receivers of the different vehicles causing death at large number. It was then, the need of the hour, that such an intelligent communication radio system, with intelligent signal processing designed at the physical layers, should come into practical existence. Thus Xgtechnology of California bought the very first cognitive radio into implementation called as Xmax radio system. This radio in comparison with the conventional “dumb” radios can operate even in the channels loaded with interference, considering them as a channel, rather than avoiding it in the name of unfit for communication. It views the channels as windows of opportunities to accommodate few secondary users for successful allocation. It is common for the conventional radios to treat the channels to be homogenous and stable and interferenceless, no wonder why it is been licensed. However a CR operates even in noisy channels and consistently check for change in the parameters such as multipath shadowing, interference etc. Once a spectral hole is found, the secondary user shall adjust its terminals according to the new channel frequency, modulation and transmission power without having to worry about the interference caused by the primary user. However the real challenges in implementing a full cognitive radio can be that the 7 layers of the OSI model needs to be flexible enough to shift to different spectrum bands upon detecting null primary user activity inducing the ISP (SDR radio with SDR), along with the necessity of an expensive front end with re-configurable transceivers and transmitters.

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II. RELATED WORK

The different pricing models in the market mechanism auctions can be so far considered to be unreliable because of the monopolism in [4] by selling the goods after bidding process that either follows the conventional two tier architecture wherein the secondary users buy the spectrum bands on a whole scale from the data centre and in the second tier ,sell these bands amongst themselves in small scale. The channels considered to be homogenous [1] and sold out as goods, wherein the secondary users were not allowed to provide valuations[7] .The network is allowed to have vast number of primary users and secondary users. Here we shall model the concepts of the combinatorial auction mechanism and try to meet their objectives. The paper shows how to divide the spectrum opportunities into different number of slots and allow the secondary user to bid for these slots with respect to time and frequency ,and apply the different payment mechanism schemes to determine the cognitive radio winners and follow the Vickrey-Clarke groove's algorithm to determine the payment. The trade is found to be fair as it upholds

- 1)Individual rationality
- 2)Incentive compatibility
- 3)No positive transfers

image may contain text embedded on to it.Detecting and recognizing these characters can be very important, and removing these is important in the context of removing indirect advertisements, and for aesthetic reasons.

Our system aims at the automatic detection of text. This is done by the algorithm. Fig. 1 shows the flow diagram of text detection algorithm. The algorithm steps are summarized as follows.

1. The network shall consist of one data centre with few number of primary users and few secondary users.The channels are considered heterogeneous wherein the transmission power can vary with different channels.
2. The combinatorial auction process takes place once the spectrum bands are sold out to the primary users, initially and then to the secondary user on a time frequency basis ,once the spectrum holes are detected.
3. The auction is conducted between the primary owner and the secondary user wherein the secondary users treat each spectrum opportunity to be bidding goods and divide them into different slots and claim their ownership according to their frequency requirement.
4. An efficient representation of the problem of the secondary users submitting the bids is captured using the Hungarian or the Kahn Monkres algorithm derived from the economics. The algorithm states that the channel allocation needs to be represented as bi-partite graph, with one side of vertices shown as the channels and the other side treated to be secondary users.
5. After calculation of valuation of each secondary users ,which is nothing but the benefit that each of the secondary user attains in purchasing that channel using the formula $V_{ij} = B \log(1 + q_{ij} * G_i / I_i + (\text{variance})^2$
6. Using the valuation,the secondary user with highest valuation will be assigned the edge weight in the bi-partite graph,representing the winner of the bidding .
7. Any auction mechanism should be extremely efficient in that the social welfare needs to be met and must be maximum.The social welfare is the summation of all the valuations of all the secondary users and can be found by $S = \sum_i \sum_j X_{ij} * V_{ij}$ where each X_{ij} represents either 0 or 1,its value for the won secondary user will be 1 and the lost secondary user will have X_{ij} to be 0 and each element X_{ij} is stored in matrix called W.
8. The cognitive winner is determined using the sorting based greedy mechanism for CRWDP
The steps are as follows :
 - i)All buyers submit their bids to the auctioneers and $W = \text{null}$
 - ii)Reordering the list to contain the elements $L = V_1/\sqrt{C_1}, V_2/\sqrt{C_2}, \dots, V_n/\sqrt{C_n}$
 - iii)For $i=1$ to n do $C_i \cap (U_j \in W \ C_j) = \text{null}$
 - iv)END IF
 - v)END FOR
 - vi)Output W.

After applying all these 8 steps, we meet the three objectives of no positive transfers,individual rationality and incentive compatibility.

The problem is np hard to solve and the social welfare is found to be maximum.

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III. THE COMBINATORIAL AUCTION AND TIME FREQUENCY FLEXIBILITY IN CR NETWORKS

The spectrum opportunity is divided into slots with respect to two dimension. The entire spectrum opportunity is represented as S . Let the time interval be Δt and the frequency interval shall be called as Δf and every $\Delta t * \Delta f$ spectrum that starts from (T_0, F_0) as $S(t_0, f_0)$. Let us say there are totally m number of slots and consider the spectrum opportunity to be unchanged in one auction interval. Hence we can map (T_0, F_0) to I where $i \in \{1, \dots, m\}$. The secondary users shall be well informed of these kind of complex mappings right from the beginning of the auction. Let there be n number of the secondary users. Each and every bid submitted by the secondary user is considered as $b = \{C_i, V_i\}$ where $C \in S$. The auction mechanism needs to find the winner following the CRWDP to provide the SU's with the incentive for revelation of the true valuation of its goods. The combinatorial auction mechanism is where the buyer will submit multiple bids to the auctioneer and every bid consists of bundle of goods he wants to buy and his valuation of that. However the entire auction mechanism must be carried out accepting two constraints. No good should be purchased by more than one buyer and no buyer is going to buy more than one bundle of goods.

IV. THE SYSTEM MODEL

The first layer here is the spectrum opportunity as well as the PU networks, the second layer is the data centre that collect the information about the spectrum opportunity from the PU's. In the third layer we have the primary operator that contact the spectrum opportunity with the data centre and sell them to the secondary users who occupy the fourth layer.

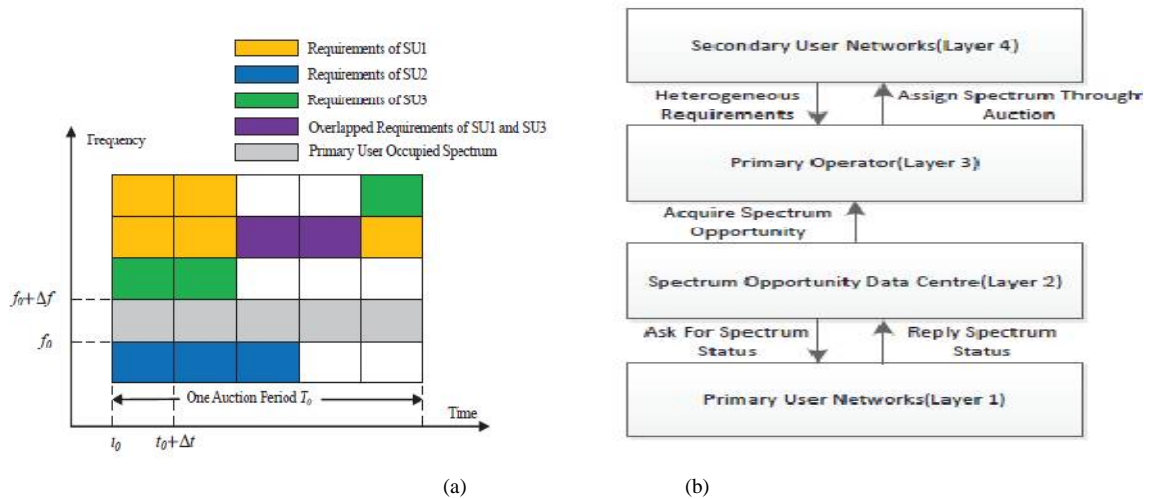


Fig. 1. (a) The PO's spectrum opportunity is depicted. (b) Cognitive radio network model

V. THE EXPERIMENTAL RESULTS

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The simulation results shows that the number of slots for SU to choose is 144 because the frequency band is divided into 24 slices. The maximum requirement for SU is 20 slots. According to the algorithm it can be seen that the social welfare is larger than $1/12 * 144$ as the np hard problem \sqrt{m} . is $1/12$. Value is the first best spectrum utilization followed by the graph indicating the norms. The start points of the auction is started throughout the points 1 to 144.

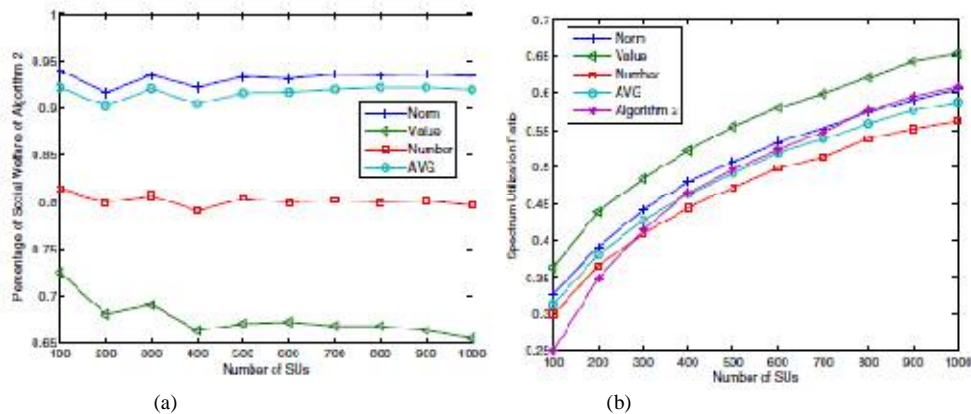


Fig.2(a)Percentage of social welfare of the Norm solution in large scale networks (b)Percentage of utilization ratio in CR networks.

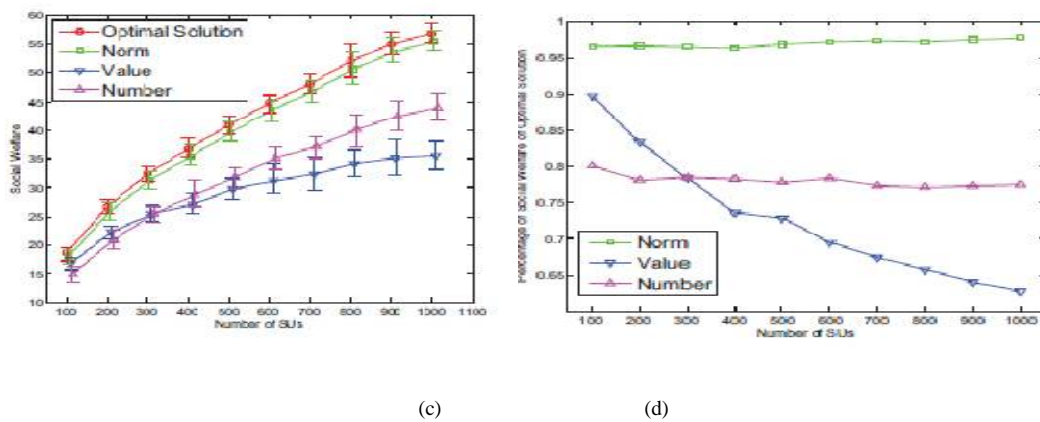


Fig. 3 (c) Under restricted model achieved social welfare (d) Social welfare under general model

VI. CONCLUSION

We have implemented the combinatorial auction mechanism between the primary owner and the secondary user when the PU activity is minimum or even null. The auction mechanism tries to match with covering all the main objectives of an auction as per the economics and the social welfare is proven to be maximum. The concept behind the combinatorial auction mechanism that, even if the secondary user's requirement is as minimum as 512Kb, if the SU attains atmost a portion of the empty channel licensed to the primary user, his requirement is fulfilled. The social welfare seems to be maximized and the three objects of truthfulness as per the economics marketing pricing models have been achieved.

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